BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 02065

SUBJECT: Lunar Exploration Mission Launch-Ability Ratings - Case 320

DATE: February 20, 1970

FROM: C. H. Eley, III

ABSTRACT

The current launch strategy for lunar missions (as presented at the October 1969, meeting of the Apollo Site Selection Board) is to use only primary site launch windows the first month, and to use primary and backup site windows in the second month. MSC is considering a revision in launch strategy to use only primary site launch windows for two, and possibly three, monthly opportunities (i.e., no backup site). For both strategies, the launch window options are examined and each mission rated as to relative launch-ability (launch-ability varies with the number and spacing of launch windows).

Using a strategy with a backup site in the second month, missions to Fra Mauro (H-2), Marius Hills (J-1), and Tycho (J-4) are found to have a lower overall launch-ability than other missions, primarily due to fewer available windows in the first month and the launch window posture in the second month (low turnaround time to the backup site). Using a strategy with only primary site windows in all monthly opportunities, the same missions plus Littrow (H-3) and Descartes may each be limited to a maximum of two launch windows 24 hours apart each month.

The absence of backup sites increases the likelihood of monthly launch slips. In order to decrease the likelihood of monthly slips, a separation in daily launch windows of 48 hours would be more desirable to permit reservicing spacecraft cryogenics for scrubs after T-11 hours, and/or permit more time for serial repair. Since the second month may be a more reliable "last chance" than the third month because of the hypergolic propellant compatibility limitation, it is suggested that consideration be given to improving launch-ability to the prime site for missions with low launch-ability ratings by (1) increasing the number of windows in the first monthly opportunity, preferably with a separation of 48 hours and/or (2) having at least two launch windows 48 hours apart in the second monthly opportunity.

An attractive alternative to realize a dual launch window strategy in the first and/or second month with a 48-hour separation might be offered by a mission design concept using a combination of both the early-launch (with a delay in lunar orbit for optimum lighting) and higher lighting angle launch windows: i.e., the current on-time nominal launch window would not be used.

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MEMORANDUM FOR FILE

1.0 INTRODUCTION

Until recently, the launch strategy for the Apollo missions utilized backup lunar landing sites to provide additional launch windows during all monthly launch opportunities. MSC has adopted a strategy for lunar exploration missions that (1) the launch window(s) in the first monthly launch opportunity be limited to the primary site, and (2) that launch to a second (or backup) site only be considered during the second monthly opportunity. While this strategy attempts to optimize science objectives for each mission, it also increases the likelihood of having to undergo a one month reschedule in launch operations at KSC.

The purpose of this memorandum is to present the effect of the above strategy with regard to launch operations. Consideration is also given to a new launch strategy now evolving in the program which involves use of a third monthly launch opportunity. The lunar exploration missions are rated as to relative launch-ability, and those missions which have the weakest probability of mission success from the standpoint of launch-ability are identified as candidates requiring additional launch windows. Suggestions are also made to improve the launch-ability for these missions to the primary site to reduce the likelihood of a one month recycle in launch operations.

2.0 ONE MONTH TURNAROUND FOR LUNAR MISSIONS

2.1 General

The ability to successfully launch an Apollo/Saturn V has been demonstrated with seven vehicles. Only one scrub has occurred (Apollo 9); however, several countdowns have come close to being scrubbed--notably Apollo 12. A probability remains that a scrub can occur during the countdown for any future lunar exploration mission because of mechanical problems or acts of God (crew illness, weather, etc.).

During the Apollo 12 countdown, it became necessary to replace a CSM-LH_2 tank after a leak was discovered. Fortunately, the planning had been such that sufficient built-in hold time was available to facilitate tank replacement before launch. Had the launch crews been unable to complete the tank change in time, the countdown would have been scrubbed and the launch would have had to be rescheduled to the next month because there was only one launch window for site 7, the primary site, in the first month.*

A scrub during the first monthly launch opportunity for any future mission will require rescheduling the launch to the next monthly opportunity. Considering the sites currently approved for the lunar exploration phase of the program, the reschedule period will be 28-30 days depending on the mission and time of year.

2.2 Spacecraft Propellant Subsystems Capability Lifetime

The exposure lifetime of the spacecraft propellant subsystems to hypergolic propellants is currently 70-75 days as determined by the LM-APS/DPS.**

Once the propellants are loaded (about one month before launch), the vehicle must therefore be launched in one of the next two monthly launch opportunities or be returned to the VAB for spacecraft removal. Detanking the hypergolic propellants would not stop the subsystem's lifetime "clock."

MSC has recently taken action to increase the compatibility lifetime to 110 days which could make a third monthly opportunity available. It is understood this is being considered for Apollo 14. The launch strategy implications in realizing a third monthly opportunity are discussed in more detail in Section 5.0.

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*A second launch window to a backup site was available; however, it was not compatible with some of the mission objectives for which the flight crew had trained.

**The current exposure lifetime of other space vehicle propellant subsystems to hypergolic propellants is: SPS - 90 days, CSM/LM RCS - 103 days, and S-IVB APS - 90 days.

2.3 Pad Operations During One-Month Turnaround

The Saturn V Countdown Working Group has completed a preliminary test flow of the operations involved in a one-month turnaround (Figure 1). Assuming worst case conditions (e.g. hypergolic propellants loaded, scrub during the latter part of launch countdown), the operations in a one-month turnaround are characterized by an almost complete inerting of the space vehicle--removal of propellants (except hypergolic propellants), gases, ordnance, batteries, water, etc., followed by a minimal amount of retest and reverification in preparation for another countdown.

A Flight Readiness Test (FRT) is not performed during a one-month turnaround because the presence of hypergolic propellants in the spacecraft prevents exercising a major portion of the Acceptance Checkout Equipment (ACE). The Countdown Demonstration Test (CDDT) is also not performed due to lack of time. However, a partial CDDT might be performed if necessary.

In sum, a one-month turnaround can be performed. However, it is recognized that this is at best a contingency operation. With increased system's exposure to hypergolic propellants and minimal reverification, a reduced confidence in the vehicle systems is a possibility. It would appear, therefore, that while we have the capability to perform a one-month turnaround, it would be preferable not to do so for launch operations.

2.4 Possible Constraints for Launch Attempt in a Third Monthly Opportunity

A potential constraint in the capability to launch in a third monthly opportunity is that the mechanical portions of the spacecraft propulsion subsystems would not have been exercised since the FRT due to the presence of hypergolic propellants.

The FRT is performed about six weeks before the first monthly opportunity. The time, therefore, between the FRT and a third monthly opportunity would be about 104 days. The lengthy exposure to hypergolic propellants, in addition to a limited overall reverification of propulsion subsystems during this period, would contribute to a reduced confidence in the mechanical portions of these subsystems.

3.0 EARTH LAUNCH WINDOWS

3.1 General

Low sun angles are still required for landing on the lunar surface. This requirement largely constrains earth launch windows to one day per month for a particular lunar site, assuming relatively fixed earth-moon transit times.

3.2 Probability of Launch vs Number of Launch Windows

A second daily launch window increases the probability of launch success within a given monthly opportunity and, hence, reduces the chances of a one-month turnaround. While it is difficult to assign exact probabilities to launch operations, the relationship between the probability of launch and the number and spacing of launch windows was examined in Reference 5 and is shown in Figure 2 (updated to reflect Apollo/Saturn V launch experience). Figure 2 indicates that from the standpoint of launch operations, two launch windows 24 hours apart offer a higher probability of launch than one launch window for any site. However, a 24-hour separation between two launch windows does not permit reservicing of spacecraft cryogenics if a scrub occurs after T-11 hours. A 48-hour span between two launch windows would be a more desirable separation to (a) allow for reservicing spacecraft cryogenics following a scrub after T-11 hours, and/or (b) permit more time for serial repair in the event of a scrub.*

3.3 Alternatives to Provide Additional Launch Windows

In order to have more than one launch window in a given monthly opportunity, there are several alternatives:

a. Have additional site(s) west of the primary site to provide backup launch window(s).

b. Expand the band of sun angles required for landing on the lunar surface (e.g. land with a higher sun angle than is currently used). An expansion of 13° in allowable sun angle would permit launching a day later than the nominal launch date.

c. Launch one day early and subsequently wait in lunar orbit for the desired sun angle at the landing site. In this case, the nominal launch window would become a backup window.

d. Use Atlantic translunar injections in addition to Pacific injections to provide two launch windows in one day.

e. Use non-free return trajectories to effect larger changes in earth-moon transit times.

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*Reference 3

Except for (a) above, the Apollo program has not used any options to provide additional launch windows during the monthly launch opportunities. MSC is considering the use of higher sun angles for lunar landings. However, it will not be known if higher sun angles are feasible until additional simulator time and/or operational experience is acquired.

3.3.1 Launching One Day "Early"

The question of launching "early" entails counting down and launching a day before the nominal launch date. After launch, the spacecraft would reach the moon a day early. Hence, it would be necessary to wait in lunar orbit for the desired sun angle at the landing site. The advantage in doing this is that the nominal launch window becomes a backup launch window for the same site in case of a scrub, thus providing an extra window 24 hours later in a monthly opportunity.

There are no constraining problems from countdown, trajectory or fuel requirements in launching a day early. However, some of the time spent in lunar orbit before landing may detract from the time available for orbital science after rendezvous. Early-launch combined with a longer transit time (instead of waiting in lunar orbit) would have the same effect.

It is recognized that launching one day early may be an extreme alternative, yet it is one way to increase the number of daily launch windows in the first monthly opportunity.

4.0 RATING LUNAR EXPLORATION SITES BY LAUNCH-ABILITY

4.1 General

The term "launch-ability" is defined here as the probability of successfully launching a specific lunar mission relative to all other missions, preferably to its designated primary site, but, if this is not possible, to a backup site before returning the space vehicle to the VAB.

4.2 Total Launch Window Posture

Since launch-ability varies directly with the number and spacing of launch windows for a specific mission relative to all other missions, all available launch windows for each mission are examined. The total launch window posture is considered to include:

Nominal (optimum) launch windows

Launch window options (early-launch, higher lighting angle)

Total number of windows (nominal plus options)

Launch window sequence

Other factors.

Table 1 lists the current lunar exploration missions and several alternate sites. Table 1 also indicates whether the sites are month dependent for launch, their ability to accept a 24-hour lighting delay, and turnaround information (as given at the last meeting of the Apollo Site Selection Board, October 30, 1969). Table 2 incorporates the information from Table 1 to show the sequence of nominal and optional windows during two monthly launch opportunities.

The optional launch windows indicated in Table 2 optimize as much as possible a launch to the prime, or science, site. The backup site has science objectives, of course, but since current hypergolic propellant compatibility makes the second monthly opportunity a "last chance," the backup site window is defined here more as a launch objective to preclude returning to the VAB.

4.2.1 Nominal Launch Windows

a. As a basic capability, all missions have one nominal (or optimum) launch window in each monthly opportunity to the prime site.

b. All missions except J-1 (Marius Hills) have a monthly launch window to a second (or backup) site. It is assumed that a backup site for the J-3 mission (Hadley) will be chosen at a later date.

4.2.2 Optional Launch Windows

The optional launch windows indicated in Table 2 are only for early-launch or higher lighting in the first and second months. Other launch window possibilities such as Atlantic translunar injections and non-free return trajectories are not considered feasible program options at the present time. However, a non-free return trajectory could become a serious candidate as the program matures.

Summarizing the launch window options in Table 2:

a. All missions could support an early-launch to the prime site.

b. All missions except J-1 (Marius Hills) and J-3 (Hadley-Apennine) have separations in the second month between the primary and backup launch windows equal to or greater than 48 hours which permit an early-launch to the backup site, if desired.

c. Three missions currently appear to be able to accept a 24-hour launch delay by landing with higher sun angles.*

4.3 Launch-Ability Ratings

Table 3 incorporates the information from Tables 1 and 2 and gives a launch-ability rating for each mission. Table 4 (in Section 6.0) is an overall summary of Table 3. Launch-ability ratings vary from "poor" to "excellent" on a relative basis. The following discusses each category.

a. Poor

One mission is rated "poor" in launch-ability.

The J-1 mission (Marius Hills) is rated the weakest in launch-ability. There is no backup site available, it is month dependent, and there is presently only one launch window during each monthly opportunity. A single window in each monthly opportunity carries with it a greater chance of launch slippage, particularly in the second month where the hypergolic compatibility lifetime constraint may become the limiting factor. Additional windows are needed in the first and/or second monthly opportunity to improve its launch-ability rating. Early-launch would accomplish this.

b. Fair

Two missions are rated "fair" in launch-ability.

1. J-4 (Tycho) - basically the same conditions as for Marius Hills except there is a backup site available to provide a second launch window during the second monthly opportunity. It is also month dependent for launch during the year. Early-launch in the first and/or second monthly opportunity would improve launch-ability rating.

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*Meeting of Apollo Site Selection Board, October 1969.

2. H-2 (Fra Mauro) - Same as J-4 (Tycho). Since a higher lighting angle for landing was recently disapproved for this mission, the only way to improve its launch-ability rating would be early-launch. Launch window separation (between primary and backup sites) in the second month barely supports a full recycle. In the event of a scrub, the relatively small separation between launch windows would leave less time for repairs, if required, than is available for other missions.

c. Good

One mission, H-3 (Littrow), is rated "good" in launch ability.*

Same comments as for H-2 except there is a better separation between the prime and backup launch windows during the second monthly opportunity.

d. Very Good

Two missions are rated "very good" in launch-ability.

1. J-2 (Copernicus)

2. J-3 (Hadley-Apennine)

Despite the fact that both these missions are month dependent and do not have a good launch window posture in the second month for turnaround to the backup site, additional options (due to the availability of higher lighting angles during each monthly opportunity) results in a rating of very good. It is felt that the availability of windows in the first month with higher lighting more than offsets the poor backup site posture in the second month.

e. Excellent

One mission is rated "excellent" in launch-ability

H-4 (Censorinus) is considered to be excellent in launch-ability as compared with all others. The mission is not month dependent and it can accept higher lighting for

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*A mission with Descartes as the prime site would also be rated "good" in launch-ability.

a 24-hour launch delay. In addition, the turnaround time during the second monthly opportunity is so long that the mission could scrub for its nominal window, try 24 hours later, scrub again and still have sufficient time remaining to perform a full-bore turnaround for an early-launch to the backup site.

5.0 LAUNCH STRATEGY WITH PRIME SITE ONLY IN ALL MONTHLY LAUNCH OPPORTUNITIES

A new launch strategy of targeting only for the prime site in either two or three monthly opportunities (without any backup site) is being considered at MSC. The absence of a backup site in a second monthly opportunity increases the likelihood of a slip from the second monthly opportunity to the third monthly opportunity with a further reduction in systems confidence. The likelihood of a third launch slip through a third monthly opportunity would be similarly increased. Ironically, a prime-site-only strategy would not effect the launch-ability of a mission to Marius Hills, rated as presently the weakest in launch-ability, because its position on the lunar surface precludes a backup site in any case.

The daily launch window options recently under consideration by MSC for the prime site--that is, early launch, nominal launch, and higher lighting--cover a span of 48 hours. However, five sites do not appear (by earlier MSC criteria) to be able to accept lunar landing with a higher lighting angle. Hence, these sites may have only two launch windows (early and nominal) 24 hours apart. These sites are:*

Fra Mauro	(H-2)
Littrow	(H-3)
Marius Hills	(J-1)
Tycho	(J-4)
Descartes	-

In section 3.2, it was pointed out that a 48-hour span between two launch windows would be a more desirable separation to (a) allow for reservicing spacecraft cryogenics following a scrub after T-11 hours, and/or (b) permit more time for serial repair in the event of a scrub.

An attractive alternative to realize a dual launch window strategy with a 48-hour separation might be offered by a mission design concept using a combination of both the early-launch

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*Unknown for sites at Alphonsus, Hyginus and Davey.

and the higher lighting angle launch windows. Such a concept would involve the use of two possibly off-nominal mission designs (optimized as a set of two) whose characteristics may still be acceptable from an overall point of view. The advantage is the realization of two launch windows in the first and/or subsequent monthly opportunities separated by 48 hours. The present mission design appears to involve the optimization of individual missions for the nominal launch dates and the use of single "off-nominal" missions to realize extra launch windows one day early or one day later.

6.0 SUMMARY

Until recently, the launch strategy for the Apollo missions utilized backup lunar landing sites to provide additional launch windows in all monthly opportunities. The current strategy is to launch in the first monthly opportunity only to the primary site with a backup site added in the second monthly opportunity to provide an additional launch window. MSC is presently considering a revised launch strategy of targeting only to the prime site in any monthly opportunity (i.e., no backup site). A strategy of launching only to the prime site during the first (or any) monthly opportunity increases the likelihood of having to reschedule the launch to the following month.

Using the current launch strategy (as given at the October meeting of the ASSB), the H-2 (Fra Mauro), J-1 (Marius Hills), and J-4 (Tycho) missions have a lower overall launch-ability than others, primarily due to the number of launch windows in the first month and their launch window posture during the second month--which may be the "last chance" because of the current hypergolic compatibility limitation. A summary matrix of the overall launch window posture and launch-ability rating for each mission is shown in Table 4.

Using the prime-site-only launch strategy (no backup sites), missions to Fra Mauro (H-2), Littrow (H-3), Marius Hills (J-1), Tycho (J-4), and Descartes may each be limited to only two daily launch windws 24 hours apart in a monthly launch opportunity. This would increase the likelihood of a slip from the second to the third monthly opportunity (or, with the present hypergolic compatibility lifetime, from the second monthly opportunity to the VAB). A launch window separation of 48 hours would be more desirable to allow for reservicing spacecraft cryogenics and/or permit more time for serial repair in the event of a scrub.

TABLE 4

SUMMARY MATRIX

MISSION	PRIME SITE	1ST MONTH	2ND MONTH	BACKUP SITE	TURNAROUND TIME TO L	LAUNCH-ABILITY	COMMENT
H-2	F. Mauro	S_e-S -	S_e-S -	L_e-L	49	Fair	No S_h
H-3	Littrow	S_e-S -	S_e-S -	L_e-L	144	Good	No S_h
H-4	Censorinus	S_e-S-S_h -	S_e-S-S_h -	L_e-L	153	Excellent	Has S_h
J-1	M. Hills	S_e-S -	S_e-S -	N/A	N/A	Poor	No S_h, No Backup Site
J-2	Copernicus	S_e-S-S_h -	S_e-S-S_h -	L	48	Very Good	Has S_h
J-3	Hadley	S_e-S-S_h -	S_e-S-S_h -	TBD	TBD	Very Good	Needs Backup Site
J-4	Tycho	S_e-S -	S_e-S -	L	72	Fair	No S_h
-	Descartes	S_e-S -	S_e-S- -	L_e-L	120	Good	No S_h

Note:

S - Nominal launch window for prime site
S_e - Early launch window for prime site (under consideration for all sites)
S_h - Higher lighting window for prime site (recently considered for sites shown)
L - Nominal launch window for backup site
L_e - Early launch window for backup site (not yet considered)

For both launch strategies discussed, the list of missions weakest in launch-ability is the same except for Littrow and Descartes. Since the second monthly opportunity may be a more reliable "last chance" because of the hypergolic compatibility limitation, it is suggested that consideration be given to improving the launch-ability and, hence, the probability of mission success for these missions by (1) increasing the number of launch windows in the first monthly opportunity (preferably to two launch windows) with a separation of 48 hours, and/or (2) having at least two launch windows 48 hours apart to the prime site in the second monthly opportunity. An alternate to provide paired windows 48 hours apart might be offered by a mission design concept using a combination of both the early-launch and higher lighting angle launch windows, recognizing that such a concept would involve the use of two possibly off-nominal mission designs (optimized as a set of two) whose characteristics may still be acceptable from an overall point of view.

C. H. Eley, III

2032-CHE-mp

Attachments
Figures 1-2
Tablee 1-3

References

1. Minutes of the Apollo Site Selection Board Meeting held at NASA Headquarters on October 30, 1969.

2. Flight Mission Assignments Document (Revised Appendix for Apollo 13, January 23, 1970).

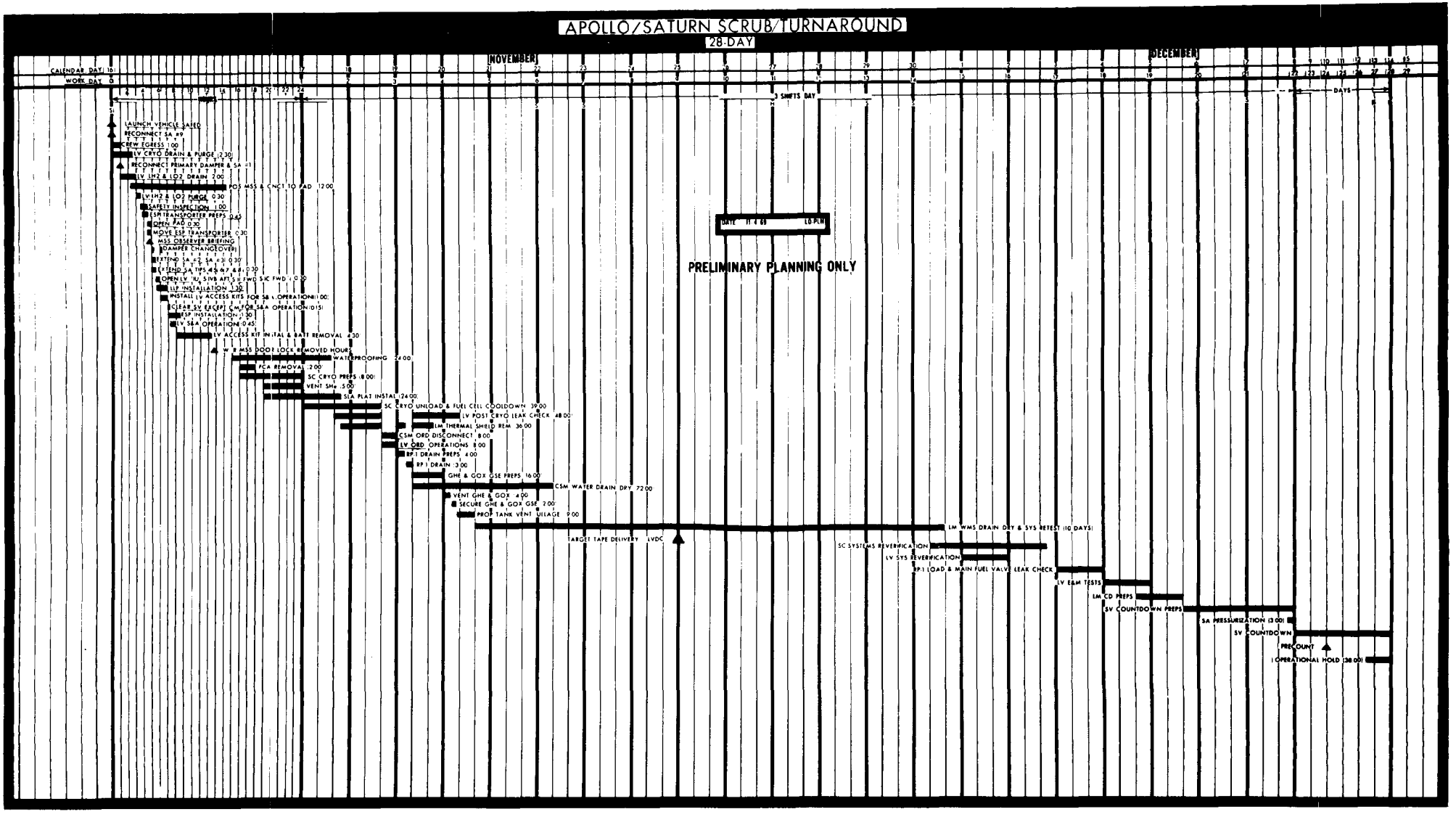
3. KSC TCP #V-40300 Vol. II; Apollo Space Vehicle Countdown-Turnaround from Scrub (AS-507) dated October 7, 1969.

4. Apollo 12 Launch Mission Rules Document.

5. "The Influence of Apollo/Saturn V Launch Operations on Lunar Site Selection - Case 330," Bellcomm Memorandum for File dated April 28, 1966, by C. H. Eley III and H. E. Stephens.

6. "Mission Analysis for Lunar Exploration Landing Sites - Case 320," Bellcomm Technical Memorandum 69-2011-4 dated October 29, 1969, by T. L. Yang.

FIGURE 1


APOLLO/SATURN SCRUB/TURNAROUND
28-DAY
NOVEMBER
DECEMBER
CALENDAR DAY
WORK DAY
3 SHIFTS DAY
DAYS
DATE 11-4-68 LO PLN
PRELIMINARY PLANNING ONLY
LAUNCH VEHICLE SAFED
RECONNECT SA #9
CREW EGRESS 1:00
LV CRYO DRAIN & PURGE 2:30
RECONNECT PRIMARY DAMPER & SA #1
LV LH2 & LO2 DRAIN 2:00
POS MSS & CNCT TO PAD 12:00
LV LH2 & LO2 PURGE 0:30
SAFETY INSPECTION 1:00
ESP TRANSPORTER PREPS 0:45
OPEN PAD 0:30
MOVE ESP TRANSPORTER 0:30
MSS OBSERVER BRIEFING
(DAMPER CHANGEOVER)
EXTEND SA #2 SA #3 0:30
EXTEND SA TIPS 4 5 6 7 & 8 0:30
OPEN LV RU S IVB AFT S II FWD S IC FWD 1:00
LLP INSTALLATION 1:30
INSTALL LV ACCESS KITS FOR S&A OPERATION 1:00
CLEAR SV EA (EXPT CM) FOR S&A OPERATION 0:15
ESP INSTALLATION 1:30
LV S&A OPERATION 0:45
LV ACCESS KIT INITIAL & BATT REMOVAL 4:30
W P MSS DOOR LOCK REMOVED HOURS
WATERPROOFING 24:00
FCA REMOVAL 2:00
SC CRYO PREPS 8:00
VENT SM's 5:00
S/A PLAT INSTAL 24:00
SC CRYO UNLOAD & FUEL CELL COOLDOWN 39:00
LV POST CRYO LEAK CHECK 48:00
LM THERMAL SHIELD REM 36:00
CSM ORD DISCONNECT 8:00
LV ORD OPERATIONS 8:00
RP-1 DRAIN PREPS 4:00
RP-1 DRAIN 3:00
GHE & GOX GSE PREPS 16:00
CSM WATER DRAIN DRY 72:00
VENT GHE & GOX 4:00
SECURE GHE & GOX GSE 2:00
PROP TANK VENT ULLAGE 9:00
LM WMS DRAIN DRY & SYS RETEST (10 DAYS)
TARGET TAPE DELIVERY LVDC
SC SYSTEMS REVERIFICATION
LV SYS REVERIFICATION
RP-1 LOAD & MAIN FUEL VALVE LEAK CHECK
LV E&M TESTS
LM CD PREPS
SV COUNTDOWN PREPS
S/A PRESSURIZATION (3:00)
SV COUNTDOWN
PRE-COUNT
OPERATIONAL HOLD (36:00)

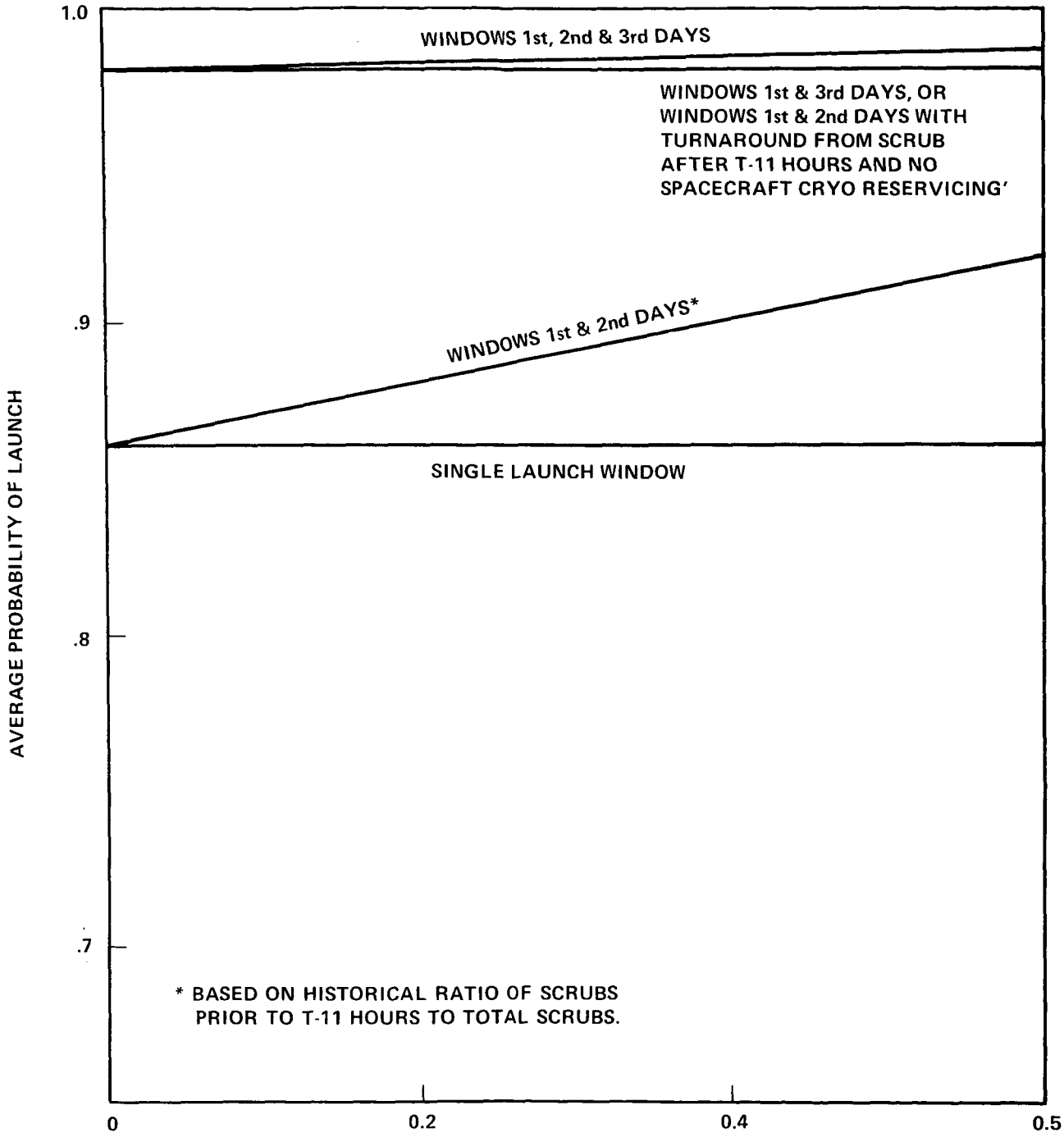


FIGURE 2 - PROBABILITY OF APOLLO/SATURN V LAUNCH AS FUNCTION OF (a) THE NUMBER AND SEQUENCE OF DAILY LAUNCH WINDOWS, AND (b) THE RATIO OF SCRUBS PRIOR TO T-11 HOURS

TABLE 1

LAUNCH-ABILITY FOR ONE MONTHLY WINDOW FOR PRIMARY SITE AND BACK-UP SITE

MISSION		PRIME SITE			BACK-UP SITE		
		PRIME SITE	MONTH DEPENDENT	ACCEPT 24 HR LAUNCH DELAY WITH HIGHER LIGHTING	B/U SITE	TURNAROUND TIME TO B/U SITE	24 HR. DELAY + FULL RECYCLE FROM PRIME TO B/U
APOLLO 13	H-2	FRA MAURO	NO	NO (2)	6R	49 HRS.	NO
APOLLO 14	H-3	LITTROW	NO	NO (2)	6R	144 HRS.	YES
APOLLO 15	H-4	CENSORINUS	NO	YES (4)	6R	153 HRS.	YES
		DESCARTES (3)	NO	NO (2)	6R	120 HRS.	YES
APOLLO 16	J-1	MARIUS HILLS	YES	NO (2)	NONE ACCESSABLE	N/A	N/A
APOLLO 17	J-2	COPERNICUS	YES	YES (4)	6R	48 HRS.	NO
APOLLO 18	J-3	HADLEY-APENNINE	YES	YES (4)	TBD-6R NOT ACCESSIBLE	TBD	DEPENDS: B/U SITE MUST BE $>30^{o}$ W. LONG.
APOLLO 19	J-4	TYCHO	YES	NO (2)	6R	72 HRS.	$\approx$ YES
		ALPHONSUS (1)	TBD	?	6R	$\approx$ 72 HRS.	$\approx$ YES
		HYGINUS (1)	TBD	?	6R	$\approx$ 90 HRS.	YES
		DAVEY (1)	TBD	?	6R	$\approx$ 70 HRS.	$\approx$ NO

(1) ALTERNATES

(2) YES IF 18^{o} - 27^{o} LIGHTING USED

(3) J-1 MISSION PRIME SITE PRIOR TO DELETION OF J-5 MISSION (APOLLO 20).

(4) PER MSC ASSB PRESENTATION, OCT. 1969

TABLE 2

LAUNCH WINDOW POSTURE (NOMINAL + OPTIONS)
FOR TWO MONTHLY OPPORTUNITIES

	OPPORTUNITY	FIRST MONTH			SECOND MONTH					
	SITE	PRIME SITE			PRIME SITE			BACKUP SITE		
	LIGHTING	$7^o - 18^o$		$18^o - 27^o$	$7^o - 18^o$		$18^o - 27^o$	$7^o - 18^o$		$18^o - 27^o$
	LAUNCH WINDOWS	EARLY	NOMINAL	NOMINAL	EARLY	NOMINAL	NOMINAL	EARLY	NOMINAL	NOMINAL
MISSION	H-2 (FRA MAURO)	S_E	S	–	S_E	S	–	–	L	–
	H-3 (LITTROW)	S_E	S	–	S_E	S	–	L_E	L	–
	H-4 (CENSORINUS)	S_E	S	S_H	S_E	S	S_E	L_E	L	–
	J-1 (MARIUS HILLS)	S_E	S	–	S_E	S	–	N/A	N/A	–
	J-2 (COPERNICUS)	S_E	S	–	S_E	S	–	–	L	–
	J-3 (HADLEY)	S_E	S	S_H	S_E	S	S_E	TBD*	TBD*	TBD*
	J-4 (TYCHO)	S_E	S	S_H	S_E	S	S_E	L_E	L	–
	DESCARTES	S_E	S	–	S_E	S	S_E	L_E	L	–

S – LAUNCH WINDOW FOR PRIME SITE (SCIENCE OBJECTIVE)

S_E – EARLY-LAUNCH WINDOW FOR PRIME SITE

S_H – HIGHER LIGHTING WINDOW FOR PRIME SITE

L – LAUNCH WINDOW FOR BACKUP SITE (LAUNCH OBJECTIVE)

L_E – EARLY-LAUNCH WINDOW FOR BACKUP SITE

* ASSUMES A BACKUP SITE WILL BE SELECTED

TABLE 3

OVERALL LAUNCH WINDOW POSTURE AND LAUNCH-ABILITY RATINGS

MISSION	NOMINAL LAUNCH WINDOW SEQUENCE FOR SCIENCE OBJ.	NOMINAL LAUNCH WINDOW SEQUENCE FOR LAUNCH OBJ.	TWO MONTH NOMINAL SEQUENCE	MONTH DEPEND	FIRST EVAL.	OPTIONAL WINDOWS FOR SCIENCE OBJECTIVE		NOMINAL PLUS OPTIONS SEQUENCE FOR SCIENCE OBJ.	SCIENCE EVAL.	OPTIONAL WINDOW FOR LAUNCH OBJECTIVE		NOMINAL PLUS PLUS OPTIONS FOR LAUNCH OBJECTIVES	TOTAL EVAL.	LAUNCH-ABILITY RATING
						EARLY LAUNCH	HIGHER LIGHTING			EARLY LAUNCH	HIGHER LIGHTING			
H-2 (F. MAURO)	S - S	L	S - S - L	NO	A	S_E - S_E	–	S_E -S -S_E -S	C	L_E	–	L_E - L	D	FAIR
H-3 (LITTROW)	S - S	L	S - S - L	NO	A	S_E - S_E	–	S_E -S -S_E -S	C	L_E	–	L_E - L	C	≈ GOOD
H-4 (CENSORINUS)	S - S	L	S - S - L	NO	A	S_E - S_E	S_H - S_H	S_E -S - S_H - S_E -S -S_H	A	L_E	–	L_E - L	A	EXCELLENT
DESCARTES	S - S	L	S - S - L	NO	A	S_E - S_E	–	S_E -S -S_E -S	C	L_E	–	L_E - L	C	GOOD
J-1 (M. HILLS)	S - S	N/A	S - S - N/A	YES	C	S_E - S_E	–	S_E -S -S_E -S	D	N/A	N/A	N/A	E	POOR
J-2 (COPERNICUS)	S - S	L	S - S - L	YES	B	S_E - S_E	S_H - S_H	S_E -S -S_H -S_E -S -S_H	B	–	–	L	B	VERY GOOD
J-3 (HADLEY)	S - S	TBD	S - S - ?	YES	B	S_E - S_E	S_H - S_H	S_E -S -S_H -S_E -S -S_H	B	TBD	TBD	TBD	B	VERY GOOD
J-4 (TYCHO)	S - S	L	S - S - L	YES	B	S_E - S_E	–	S_E -S -S_E -S	D	L_E	–	L_E - L	D	FAIR

S – LAUNCH WINDOW FOR PRIME SITE (SCIENCE OBJECTIVE)

S_E – EARLY-LAUNCH WINDOW FOR PRIME SITE

S_H – HIGHER LIGHTING WINDOW FOR PRIME SITE

L – LAUNCH WINDOW FOR BACKUP SITE (LAUNCH OBJECTIVE)

L_E – EARLY-LAUNCH WINDOW FOR BACKUP SITE